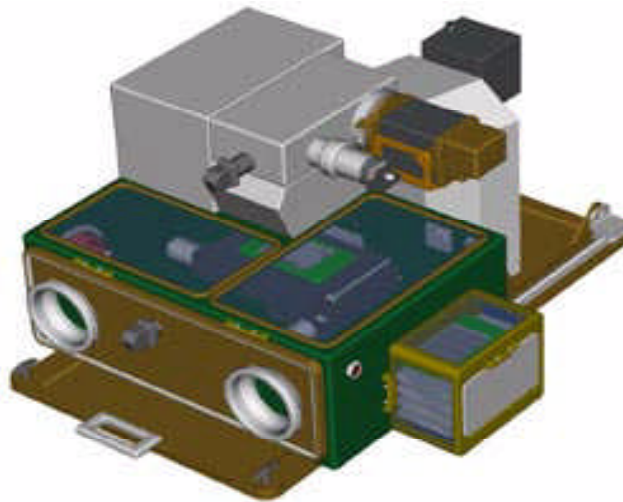


Light Microscopy Module: An On-Orbit Microscope Planned for the Fluids and Combustion Facility on the International Space Station

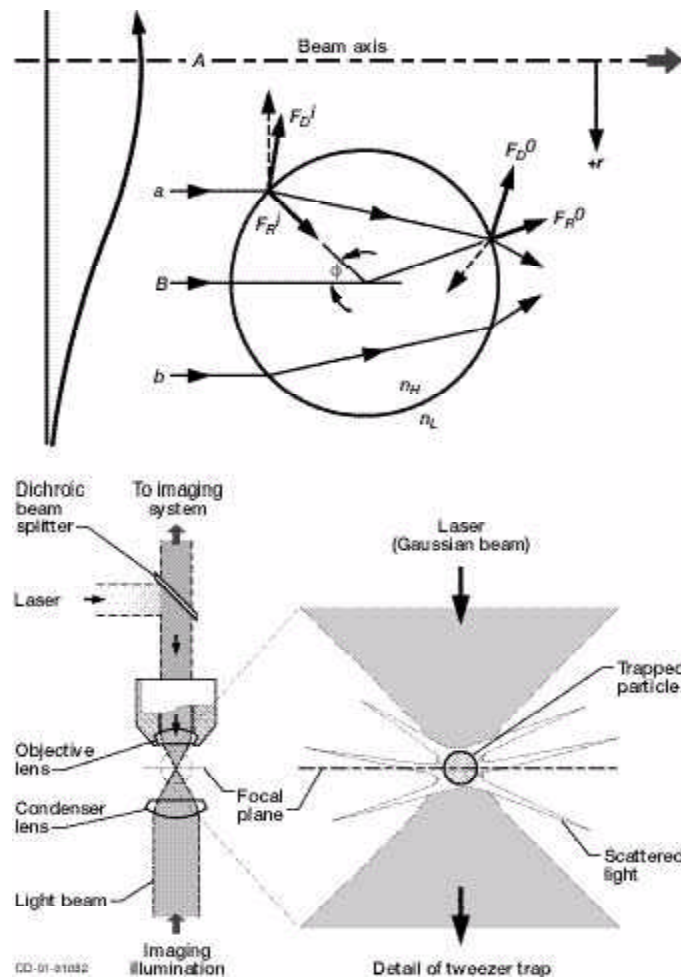
The Light Microscopy Module (LMM) is planned as a fully remotely controllable on-orbit microscope subrack facility, allowing flexible scheduling and control of fluids and biology experiments within NASA Glenn Research Center's Fluids and Combustion Facility on the International Space Station.

Within the Fluids and Combustion Facility, four fluids physics experiments will utilize an instrument built around a light microscope. These experiments are the Constrained Vapor Bubble experiment (Peter C. Wayner of Rensselaer Polytechnic Institute), the Physics of Hard Spheres Experiment-2 (Paul M. Chaikin of Princeton University), the Physics of Colloids in Space-2 experiment (David A. Weitz of Harvard University), and the Low Volume Fraction Colloidal Assembly experiment (Arjun G. Yodh of the University of Pennsylvania). The first experiment investigates heat conductance in microgravity as a function of liquid volume and heat flow rate to determine, in detail, the transport process characteristics in a curved liquid film. The other three experiments investigate various complementary aspects of the nucleation, growth, structure, and properties of colloidal crystals in microgravity and the effects of micromanipulation upon their properties. Key diagnostic capabilities for meeting the science requirements of the four experiments include video microscopy to observe sample features including basic structures and dynamics, interferometry to measure vapor bubble thin film thickness, laser tweezers for colloidal particle manipulation and patterning, confocal microscopy to provide enhanced three-dimensional visualization of colloidal structures, and spectrophotometry to measure colloidal crystal photonic properties.



Light microscopy module on rotating mounting plate.

The LMM concept is built around a commercially available upright style microscope. The microscope will house several different objectives, corresponding to magnifications of 310, 350, 363, and 3100. Features of the LMM include cameras, an interchangeable laser tweezer (or confocal) package, tungsten halogen lamps, an auxiliary fluids container with gloveports, an experiment transfer module, and a rotating mounting plate. The multiport imaging head on the top of the microscope provides a motorized slider to select the sensor or sensors to which the images are directed. The rotating mounting plate allows the LMM to be rotated for easy access to the sample area when in a nonoperating mode. The auxiliary fluids container prevents liquid droplets (immersion oil or leaking sample material) from escaping into the cabin or into electronics in the Fluids and Combustion Facility. Glove ports allow access to the sample area for cleaning, before opening the box for sample platen changeout or reconfiguration. The experiment transfer module, which can accommodate up to five sample cell platens, is configured adjacent to the auxiliary fluids container, which has a pass-through for the samples. The experiment transfer module will be loaded with sample platens on the ground and will provide contained storage until the samples are used in the experiment.



Concept of laser tweezers: trapping of particles by radiation pressure.

Laser tweezers will be implemented using a custom-built system based on a 1064-nm Nd:YAG laser, beam-focusing optics, and two acousto-optic deflectors to steer the trap within the field of view of the microscope. Laser tweezers simply is the trapping of a colloidal particle using radiation pressure by focusing a laser beam through a high numerical aperture lens and striking the particle. Tweezers will be employed to displace a particle by one or more lattice constants from its equilibrium position. In addition, the tweezers will be scanned through a fixed array of points across the field of view to induce patterns that are either commensurate or incommensurate with the equilibrium configuration of the colloidal crystal. They also will be used to measure the viscosity of the fluid. A particle is trapped and video images taken as it is translated in an oscillatory fashion through the field of view. The velocity just before the particle falls out of the trap is measured from the video record and, along with the known force and particle diameter, is used to calculate the sample dynamic viscosity (or crystal shear modulus).

During 2000, the LMM Team at Glenn successfully used laser tweezers to trap colloidal particles. Currently, the LMM project is in the requirements definition and preliminary design phase. A preliminary design review will be conducted in mid-2001. This work was performed under NASA contracts NAS3-99155 (Federal Data Corporation) and NAS3-98008 (Dynacs).

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